Design and Development of Vanadium Redox Flow Battery (V-RFB) Cell Stack

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Abstract

The purpose of this paper is to demonstrate the summarization of work on experimental characterisation of vanadium redox flow battery (V-RFB). The aim of the study is to design a functional prototype of V-RFB and investigate the performance of characterisation of V-RFB at specific current density. Experiment was carried on 110.25cm^2 prototype of unit cell. The results from the performance test of the developed V-RFB including few obstacles faced have been presented and analysed. Further works is discussed.

1 Introduction

In recent years, researcher has shown an increasing attention to the issue of energy security worldwide. With today's modern economics development, demands on the stability in energy security has multiplies for future accessibility. First and foremost, energy security was primarily associated with the availability of natural resources for energy consumption. New threats for energy security have arisen when the world competes for energy resources due to the increase in industrialization process by every countries. This leads to the possibility of the volatility in the crude oil price. Hence, this encourages researchers, industries and government to embark into a new research for energy storage technologies.

Some approaches for the new energy storage technologies have been introduced in order to improve and manage the amount of power required to create and supply energy for infrastructure as well as bring profits in terms of cost saving for both utilities and consumers. Energy storage can be classify into several types which are mechanical, electrical energy storage and electrochemical energy storage. Among those, Fernao Pires et al. [1] stated that electrochemical energy storage system is still widely used storage and have the strongest advantages such as quick load demand response, high efficiency, eco-friendly and provide dependable solution for applications that is mobile or stationary. Lead Acid (LA), Lithium Ion (Li-ion), Nickel Cadmium (Ni-Cd), Fuel Cell (FC) and Redox Flow Battery (RFB) are some of the energy storage listed down under the category of electrochemical. Among all, vanadium redox flow battery (V-RFB) is the most developed and the most close to commercialization compared to other types of RFB [2].

Historically, V-RFB has been patented by Maria Skyllas-Kazacos and by late 1980's, it is demonstrated successfully at University of New South Wales. V-RFB has a characteristic of a rechargeable flow battery which can produce energy by utilizing vanadium redox solution where it store chemical potential energy by redox reaction. Parasuraman et al. [3] Ki Hyun Kim et al. [4] mentioned that so far, V-RFB is one of the most promising technology and it is satisfactorily to be used for a wide range of renewable energy applications due to its safeness, long lasting and capable of being scaled. Moreover, Toshio Shigematsu et al. [5] also reported that V-RFB storage is especially favourable because it uses the same redox couple at both electrodes and the capacity of the battery does not lessen even when both side of couple are mixed via the membrane.

Recent research focuses more on the V-RFB characteristics but there is a limited research on the characterisation of the cell stack of V-RFB. This paper will be the extended research to achieve the potential performance characterisation of V-RFB. Different methods and approaches to solve this problem are presented and discussed. The performance characterisation of V-RFB is analysed based on the state of charge and discharge of the battery. From the fundamental theory, performance of the battery could influence the V-RFB efficiency. The better the performance of the battery, the higher the efficiency of V-RFB can be achieved.

2 Energy Storage

Energy storage has been a major discussion in energy news due to its recognition by researchers to be one of the primary energy that can replace fossil fuels. Whereas, to replace fossil fuels by using electricity, electric vehicle with batteries are the promising technology. Thus, in the next future energy storage is anticipated to grow worldwide due to the expansion of intermittent renewable energy sources. Abdussalam Alamri et al. [6] said that wind, solar and wave which are intermittent renewable energy sources are extremely variable output because usually the energy generation is independent of the load in where renewable energy resources provides high energy generation. Renewable energy is difficult to be controlled thus, it has a restrained contribution towards generation of power. Toshio Shigematsu et al. [5] also stated